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LINK ANALYSIS OF HIGH THROUGHPUT SPACECRAFT COMMUNICATION SYSTEMS FOR FUTURE SCIENCE MISSIONS

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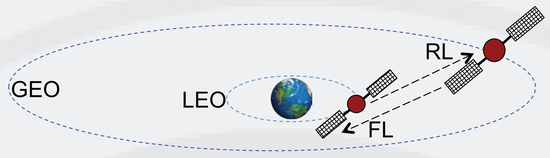
I. INTRODUCTION

- In the next ten years NASA plans to launch several spacecraft into Low Earth Orbit (LEO) for remote sensing of the Earth with instruments that will accumulate several hundred gigabits of data per orbit
- The ability to handle such a large volume of science data per orbit far exceeds the capabilities of NASA's current space and ground assets
- The paper proposes two solutions: first, a high data rate link between the LEO spacecraft and ground via relay satellite in geostationary orbit (GEO). Second, a high data rate direct to ground link from LEO

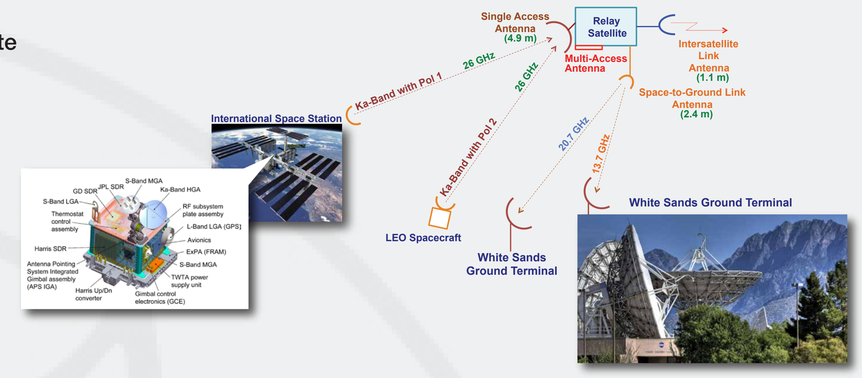
II. KA-BAND SPACE-TO-SPACE LEO-TO-GEO LINK

The relay satellites are located in GEO. The LEO-to-GEO link is designated as the return link (RL) to the relay satellite and operates at Ka-band (25.25 to 27.0 GHz) frequencies. The GEO-to-LEO forward link (FL) operates at K-band (22.55 to 23.55 GHz) frequencies.

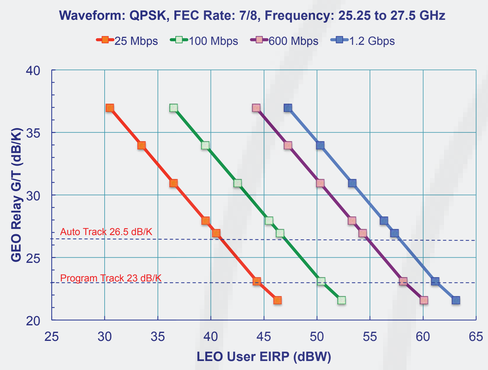
LEO-TO-GEO RELAY SATELLITE LINK



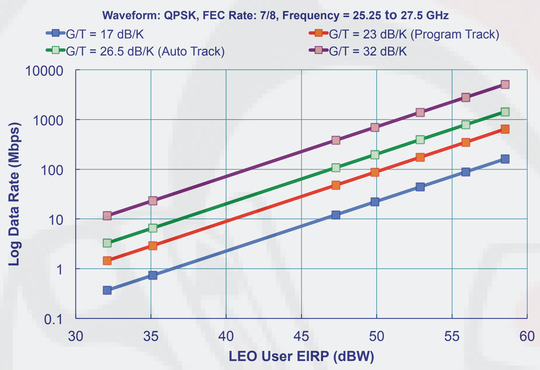
SPACE-TO-SPACE LINKS AND SPACE-TO-GROUND LINKS VIA RELAY SATELLITE



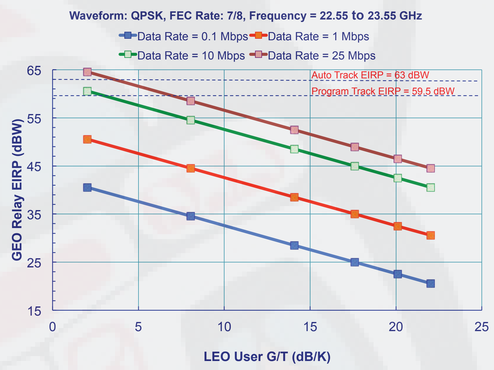
RELAY SATELLITE G/T VS. LEO SPACECRAFT EIRP (LEO-TO-GEO K_a-BAND SINGLE ACCESS RETURN LINK)



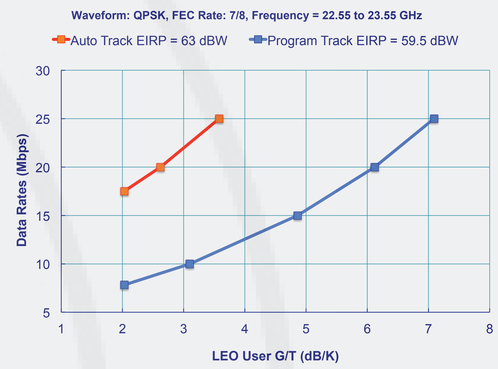
ACHIEVABLE DATA RATES VS. LEO SPACECRAFT EIRP (LEO-TO- GEO K_a-BAND SINGLE ACCESS RETURN LINK)



RELAY SATELLITE EIRP VS. LEO SPACECRAFT G/T (GEO-TO-LEO K_a-BAND SINGLE ACCESS FORWARD LINK)



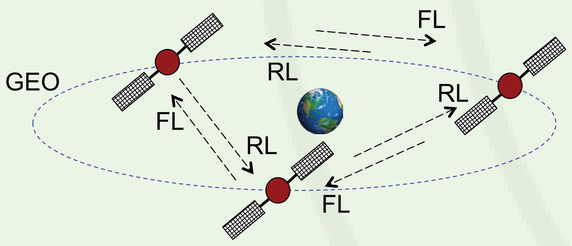
ACHIEVABLE DATA RATE VS. LEO SPACECRAFT G/T (GEO-TO-LEO K_a-BAND SINGLE ACCESS FORWARD LINK)



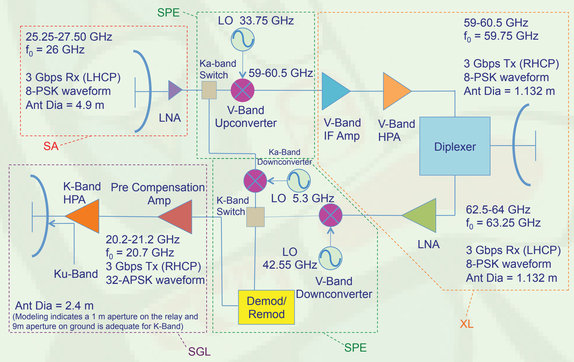
III. V-BAND GEO-TO-GEO INTERSATELLITE LINKS

The forward (FL) and return (RL) links operate at V-band frequencies (59 to 64 GHz), but with opposite sense of polarization to minimize interference

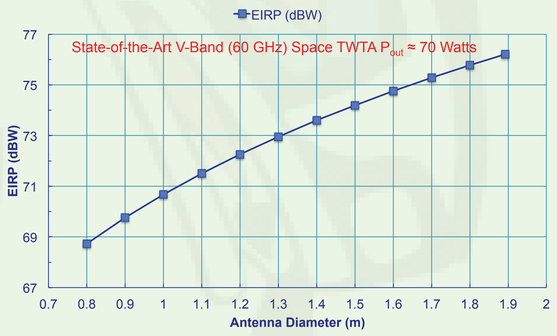
GEO-TO-GEO INTERSATELLITE LINKS



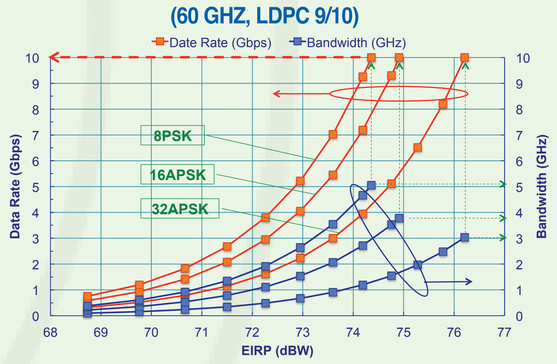
TX AND RX CHAIN ONBOARD THE RELAY SATELLITE FOR SPACE-TO-SPACE LINKS AND SPACE-TO-GROUND LINKS



RELAY SATELLITE EIRP VS. ANTENNA DIAMETER



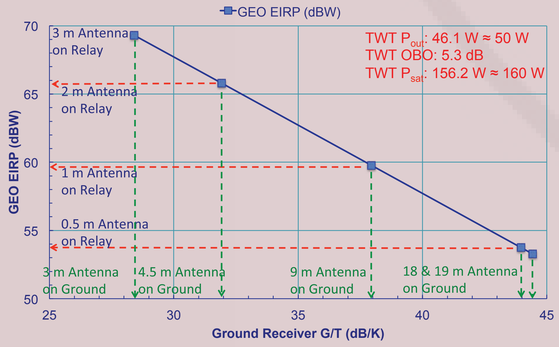
DATA RATE AND BANDWIDTH VS. RELAY SATELLITE EIRP (60 GHZ, LDPC 9/10)



IV. K-BAND GEO-TO-GROUND LINK

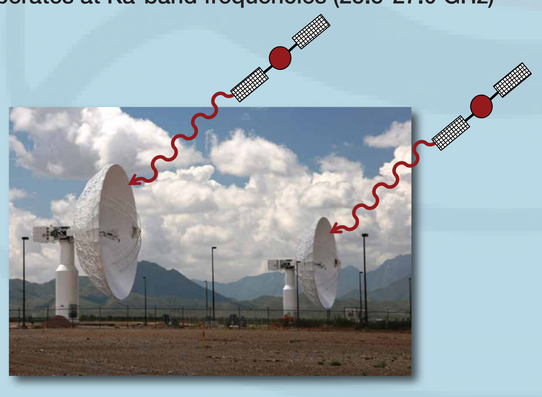
The relay satellite to ground station down link operates at K-band frequencies (20.2 to 21.2 GHz)

RELAY SATELLITE EIRP VS. GROUND RECEIVER G/T

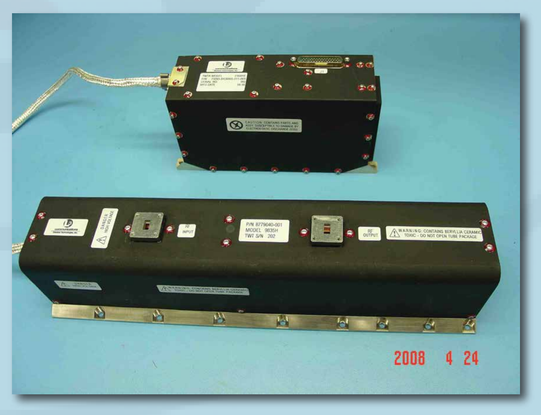


V. KA-BAND LEO-TO-GROUND LINK

The LEO spacecraft to a ground station down link operates at Ka-band frequencies (25.5-27.0 GHz)

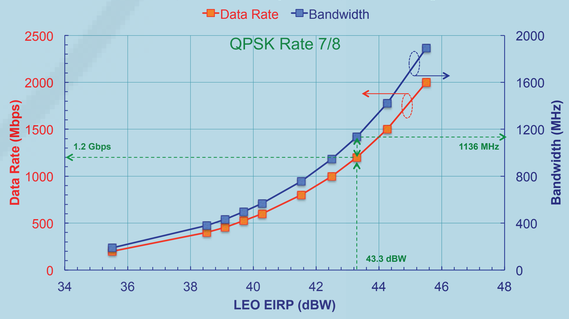


HIGH POWER HIGH EFFICIENCY TRAVELING-WAVE TUBE AMPLIFIER (TWTA) FOR SPACE-TO-GROUND LINKS



DATA RATE AND BANDWIDTH VS. LEO SPACECRAFT EIRP (LEO USER TERMINAL TO GROUND (WSC))

LEO User Tx Ant Dia: 0.5 m, Tx Frequency: 26 GHz, User Ant Dia: 0.5 m,
G/T: 14.8 dB/K, 99% Availability at WSC, Elevation Angles: ≈15°



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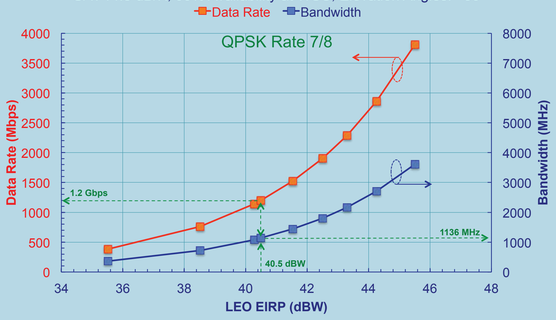
LEO User Tx Ant Dia: 0.5 m, Tx Frequency: 26 GHz, User Ant Dia: 0.5 m,
G/T: 14.8 dB/K, 99% Availability at WSC, Elevation Angles: ≈30°



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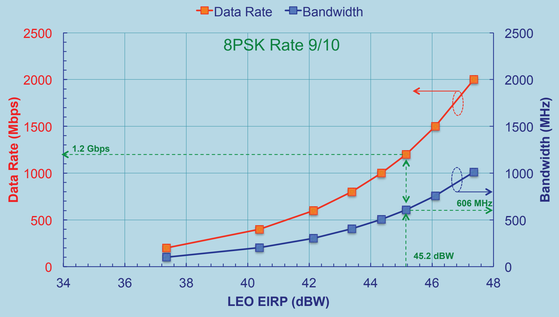

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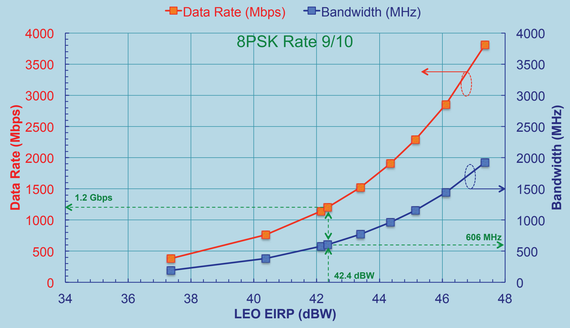

VI. CONCLUSIONS

Results from computer simulations carried out for high-data-rate LEO-to-GEO, GEO-to-GEO, GEO-to-ground, and LEO-to-ground links to down load large volume of science data are presented

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